Mumbai Covid 19 Localisation Update: Emigration has reduced new cases and prompted celebrations — It's too soon to celebrate

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Summary

This article is an update of an analysis we wrote about at the end of May.

We have a team led by two students: first Hasna Virk a first year Biomedical Sciences student at University of Warwick in the UK who

started looking into what was happening in India back in April and then she was joined by Andre Nemec who is hoping Bristol University, UK opens in the September so he can start on his Economics degree. Andre joined when we decided to focus on two radically different neighbourhoods right next to each other in Mumbai India. Mumbai City District and the Dharavi Slum. And then we were fortunate to be introduced to Praja.org who have helped us find very detailed information that was critical to understanding the situation in Mumbai.

This article is our story of efforts to set up our Covid 19 Localisation model and how we had some initial conclusions that illustrated very well why Localising the model is critical: the best strategy and actions for each neighbourhood were totally different. However we were very frustrated by the reactions of the media and while the local residents were very interested in our analysis it became clear we were missing a major element of the story: migration out of the area was changing everything.

Mumbai City District (MCD) officially contains Dharavi but they are nothing like each other. MCD ex-Dharavi (MCDXD) is an economically well-off area that has attracted an influx of young upwardly mobile families and wealthy elderly residents. Dharavi is one of the world's largest and most densely populated slums. Most people know it from the movie 'Slumdog Millionaire'. Figure 1 shows just a few of the reasons why it is nonsensical to try to analyse them together: they are unrecognisably different. But this is the tendency in the Covid 19 Crisis has been to treat the outbreak as if it is the same everywhere and apply blanket lockdowns everywhere. This just doesn't work here. The population density is 14x higher in Dharavi; the age demographics are totally different; life expectancy is double in MCDXD; The impact of migration is profound in Dharavi and almost unnoticeable in MCDXD; the way the outbreak is spreading in the two districts is unrecognisably different: its growing fast in MCD whereas in Dharavi the new cases peaked in May and dropped by almost half in June. It makes no sense at all to try to analyse these two neighbourhoods together. But this is what most governments and health authorities have been doing with Covid 19.

A notable exception is the BMC in Mumbai. They have implemented very strict measures across the board, but they have also adopted radically different approaches within these neighbourhoods. The BMC have also

made an effort to be transparent. They have published what we believe is a **world class dataset at a neighbourhood level.** As we have analysed and understood this, we have been increasingly impressed with the handling of the Covid 19 crisis in Mumbai so far. Our analysis shows the actions by the BMC have saved thousands of lives in MCDXD and Dharavi.

The is not nearly the end of the story. The media have been celebrating what appears to be a huge win in the battle with Covid 19 in Dharavi. But our analysis also shows even bigger challenges lie ahead and there are potentially achievable actions that show explicitly what you have to believe to plan for and mitigate the impact of Covid 19 over the coming months.

The rest of this article traces through the history of our work in Mumbai and our evolving and highly productive partnership with the staff at Praja.org where we held a webinar last week to train 72 staff on how to use our Covid 19 Localisation model. Why are all these people being trained? Because we believe it is not enough to do some clever analysis. It actually matters very little if we (the authors) understand what is happening in Mumbai: Viral outbreaks are local, the resources to cope with the health problems are local, the actions of people on the ground are obviously local. The understanding must also be local.

By now almost everyone understands by now Covid 19 is a highly infectious viral outbreak. And there is also increasing evidence that in fact it is relatively mild in terms of pathology overall at the large scale

population level with Current Fatality Rate of around 3% and many cases mild to undetectable cases so the Inferred Fatality Rate is in most locations is well below 1%. However, the speed of the outbreak and the high proportion of asymptomatic transmission has created crisis conditions in many locations. And yet local conditions matter so much the impact in other locations has been modest. This combination of uncertainty, vastly different outcomes and vastly different reactions to the outbreak has created something like a mythology around Covid 19 with wild swings in public opinion and confusion about what to do. By being transparent with data at a neighbourhood level, the BMC are breaking down the mythology and confusion and making it possible to identify rational and effective responses. But we believe identifying rational responses is not enough: we must engage young people who are least directly impacted by Covid 19, but a critical part of any solution because they are part of the asymptomatic transmission of Covid 19 to the more vulnerable.

Chapter 1 is the historical record of how we go to where we are today and is here to show how important it is to keep digging to understand fully what is happening in any local area. Subsequent data on Migration out of the area have demonstrated that we had much to learn. Chapter 2 brings us up to date: we believe the simulation is much more accurate in Dharavi. This shows its prospects are much better than we initially thought. In Chapter 3 there are some observations on the impact of actions already taken in Mumbai City District, where there is still a big opportunity. Chapter 4 is a waiting for analysis on migration out of

Mumbai. We have done similar analysis in Indonesia; it is urgently needed in India. Chapter 5 discusses implications in every city with distinct neighbourhoods across the world. Out of all of this we have some ideas that undoubtedly are on the minds of the people on the ground. Our analysis shows they have been doing a remarkable job of identify actions that mitigate impact of Covid 19 in their local area and also recognise that some residents have no choice and must return to work to survive or leave the area.

These are incredibly difficult trade-offs. We can't hope as outsiders to fully understand all the nuances that must be considered to balance these pressures. We hope that what we have done here will nevertheless help the authorities and residents in Dharavi and Mumbai City District in moving forward in tackling the pandemic and making good judgements about what actions can make a positive impact.

There are also obvious limits to what we have analysed. We have not attempted to weigh up or quantify the knock-on economic impact of policies that alleviate suffering from Covid 19. It is self-evident there is a significant economic cost. That is perhaps where we will attempt to investigate next.

By providing serious, well researched and validated analytic tools to young people who have a thirst to understand the epidemic we have a better chance to achieve community collaboration in the battle with Covid 19. That is why we are partnering with Praja.org to help young

people understand the epidemic and become active contributors to finding and delivering better outcomes.

This is not just a story about Dharavi and Mumbai City District. This is a microcosm of events across India and other countries where large-scale migrations are happening. These migrations result in some cases out of desperation, as arguably is the case in Dharavi, in other cases due to economic opportunity, and in still others due to tradition, such as the annual migrations around religious festivals. There is much to learn from this case in Mumbai for all of these situations. We are hopeful the lessons here will transfer elsewhere, and we are offering tools to help in ensuring they do so.

Chapter 1: End of May: Battling Covid-19 one neighbourhood at a time: How to do it in Mumbai, our first attempt to understand and recommend helpful ideas

At the end of May we wrote:

Almost everyone understands by now Covid-19 is a highly infectious viral outbreak. Most people also understand that outbreaks happen locally, spread locally and must be fought locally. But most Covid-19 models are not local: the great majority deliver national-level recommendations and ‘one size fits all’ battle plans. These have helped but have increasingly been criticised for one fundamental flaw: they can’t tell you what to do in your village, town, hospital catchment area, or city. We must do much

better. We need an accurate localisation model to make battle plans – not for scientists alone but one that can be used by teenagers (or anybody) in communities that need to understand what actions will help them and how and why they will. So, with this need in mind, we created a localization model and validated it in dozens of local areas across the world.

Its power is shown, for example, in two areas right next to each other within Mumbai: the mostly middle-class Mumbai City District (MCD), and the Dharavi Slum on its fringes, which is officially contained with the MCD. These areas are radically different from one another, in terms of population density, age profile, travel and social behaviour patterns, and levels of health and nutrition. It should therefore come as no surprise that there is no one effective strategy for these two neighbourhoods.

We analysed three scenarios In Mumbai City District, excluding Dharavi (MCDXD, Figure 1). **Scenario A represents an immediate release of the lockdown**, where people revert to normal behaviours, but show some caution until the peak of new cases passes. The number of deaths, at 32,060, is a shocking figure,

29 May Dharavi Covid 19 Localisation Model

29 May Mumbai City District — Dharavi Covid 19 Localisation Model

but this benchmarks closely to the situation in Lombardy across these scenarios, which has a similar average age of 45 to that in MCDXD. **Scenario B shows a more gradual lockdown release**, which limits total deaths to 27,260. This reduction arises because "R" (*the disease replication rate*) is close to 1.0, so, persisting with lock-down raises the number of survivors. However, the peak in cases, at 13 September (day 240), still overwhelms the healthcare system. **Scenario C is a managed set of measures to further cut transmission of Covid-19.** This strategy actually relaxes contact rates for a short time, but then reduces them sufficiently to keep the number of active cases near to the limits of hospital capacity. This can be achieved with hygiene and test-and-trace measures. Such a 'smart lockdown' could potentially cut deaths further, to 22,340. None of these scenarios assume any improvements in treatment or viable vaccine, so Scenario C not only saves lives but also buys time to benefit from such discoveries.

The situation in Dharavi could not be more different (Figure 2). Ultra-high crowding (250,000 per sq. km) and poor sanitation mean that no plausible set of policies can cut the high R-rate to anywhere near 1.0, so the rates of cases and deaths start 20 days later but happen twice as fast. The situation leaves little room for improvement. **Scenario A shows that if the lockdown is released immediately,** 7,788 deaths could occur — a shocking figure given the young population (with an average age of 30), but with a death rate of 1.1%, this is still less than the 1.3% of MCDXD. The high total is due to the prevalence of other illnesses and generally poor health. This scenario presents a terrifying but short period of high death rate, while the surviving population would quickly become resistant. This would be a brave choice but — other things being equal — might actually *save* lives in other ways by mitigating economic hardship.

Unfortunately, the timing could not be worse for Dharavi — flooding from the impending Monsoon will likely spread malaria, cholera and typhoid, multiplying the death toll from https://www.dropbox.com/s/ypy1rbxv6igjnwe/Screenshot%202020-07-08%2017.59.22.png?dl=0Covid-19. In such circumstances, it would be a cruel choice to let the virus rip through the neighbourhood, as in Scenario A. Any compromise of the immune system severely impacts on survivability, even where hospital care is available. With few exceptions, comorbidities (asthma, COPD, cancer, diabetes, Hypertension) as well as any other disease contracted at the same time as Covid 19 is more dangerous outbreak Such a sharp surge of cases would overwhelm

hospitals that are already stretched by Monsoon related diseases, so the true death toll could be much worse. **Scenario B is a realistic continuation of measures currently in place in Dharavi** but adjusted to allow residents some freedoms that sustain their general level of health, such as by providing urgent, significant access to additional food and medicine. The Covid-19 deaths may not appear materially lower, at 7,519, but that ignores the potentially higher rates of non-Covid deaths in Scenario A. **Scenario C attempts to delay the peak of the outbreak until after the Monsoon.** However, the required reduction in the R-rate to about 0.8 would call for unrealistically stringent contact and hygiene measures sufficient to reduce infection rates to 38% of those happening today. Even with such measures, this strategy only cuts the number of deaths to 7,119 and would inflict months of economic suffering on a population already struggling with poor levels of health and nutrition, resulting in many more deaths from other causes.

Dharavi faces a difficult challenge to get through the Covid-19 outbreak in a way that avoids the worst impacts of the Monsoon, but there seems no option but to help the residents survive where they are. This means providing enough food and medicine to cope as well as possible over

the coming weeks while treating mild cases on site, so that hospitals can focus on more serious cases. It is also vital to clear sewers so as to reduce flooding and thereby hold down the mortality rate resulting from other diseases. After testing, to confirm that the outbreak has indeed passed, Dharavi residents — most of whom would no longer be susceptible — would be able to resume their interactions with the rest of the city.

In Summary, at the end of May we thought Dharavi's situation was going to mainly hinge on how well the residents could cope during the Monsoon; it looked very unlikely the path could be altered much. However, we believed there were big opportunities that could have a positive impact in Mumbai City District. We didn't predict what was about to happen.

Chapter 2: Beginning of June: Totally unexpected, new cases are dropping. That's great, but what's really happening? It's not what it seems.

We were feeling pretty confident at the end of May. We had real insight into what was happening in Mumbai City District and Dharavi. We had identified major differences between the two districts set up our model

for both areas and found solid reasons why the two areas had to follow very different paths: because they are very different, and everything we did with the model suggested Dharavi was almost beyond help. It is too densely populated and too unhygienic to stop Covid-19 infections from ripping through Dharavi in a matter of weeks and infecting everyone. And we thought the model was looking like it was corresponding well with the data we had, which we were unsure about at the time, but the close correspondence gave us some confidence we seemed to be on the right track.

29 May Dharavi Covid 19 Localisation Model

We reasoned that, since this appalling outcome was unavoidable, imposing lockdown restrictions would only pile more suffering on a desperate community. But our confidence in that conclusion was shaken when local members of our team exclaimed that is completely nuts! The

Monsoon on top of an explosion of COVID-19 infections is going to be absolutely terrible: Cholera, Malaria, Typhoid will multiply the suffering. We were feeling pretty helpless and frustrated because although we thought we had something that could help, it was really hard to get anyone interested in our findings.

Undeterred, we shared Chapter 1 with some journalists, and we realised why this had been the case: the data on new cases was starting to diverge from what we had predicted in Dharavi. The news stories were reporting a triumph over the coronavirus in Dharavi. New cases per day dropped from 43 per day in May, to 27. Problem solved! Covid-19 is under control! Dharavi, champion in overcoming the odds, is one of the unlikeliest stories of the Covid-19 pandemic.

How can that be? It doesn't make any logical sense. But it's happening and our model was drifting off track especially for new cases.

Then we had a meeting with our locally based team at Praja.org to go through things and try to figure things out. At the same time, there were news reports of people leaving Dharavi to get out of the city ahead of the Monsoon. We asked Praja for help us to quantify the scale of the outward migration. The answer: at least half the population had left Dharavi since the lockdown was imposed during the first week in May.

Do the math: if half the population leaves, is 27 cases per day in the first week of June good news or bad news?

With 43 cases per day in May, if half the population leaves, all else being equal, the rate should drop to 21.5 cases per day. Ok, we don't know exactly when everyone left, but 21.5 cases are not where we are at. We are at 27. That's a 25% increase. The infections are not dropping, they are still increasing, pretty fast.

So, are we right, and the news about stamping on the virus in Dharavi is an illusion? Or is it a genuine triumph?

We added the outward migration into our model, then ran the simulation including migration and compared it to data from Dharavi. The migration, no surprise, reduces the number of susceptible people to half

over a very short period. After a short delay, this is then reflected in the recorded new cases and the growth in deaths is levelling off:

1 July Dharavi Covid 19 Localisation Model

Looks like good news. But here's what the model says would happen next:

Infections and deaths explode.

Figure 9 shows the big picture — or, rather, it's a small window on a wider view since you need to look at everything to understand what's going on:

It's better to look at the model in full, and you can do that here. But let us summarise in this scenario, with no other intervention other than half of the population leaving Dharavi in the last three weeks of May, the model tracks almost exactly what has happened: the number of new cases drop in line with the data. But then everything explodes new infections, the total infected, hospital overcrowding and, eventually, the number of deaths. And compared to the earlier projection without the migration it happens faster and its over sooner.

1 July Dharavi Covid 19 Localisation Model Dashboard

It's worth also noting the dashboard has information that is not generally reported: Susceptible, Total Migrants, Total Infections, Hospital Occupancy and of course there is a projection for everything which is also not generally reported. All of this unreported information is strategic.

The explosion in new cases can't be good news. But it's not the whole story because the local authorities have made other incredible efforts. We have added these interventions into the simulation to see what happens then.

By Mid-May Mumbai Live reported the BMC had tested and traced and have told more than 30,000 people to isolate themselves at home, while placing more than 6500 vulnerable people in institutional quarantine:

This changes the picture significantly:

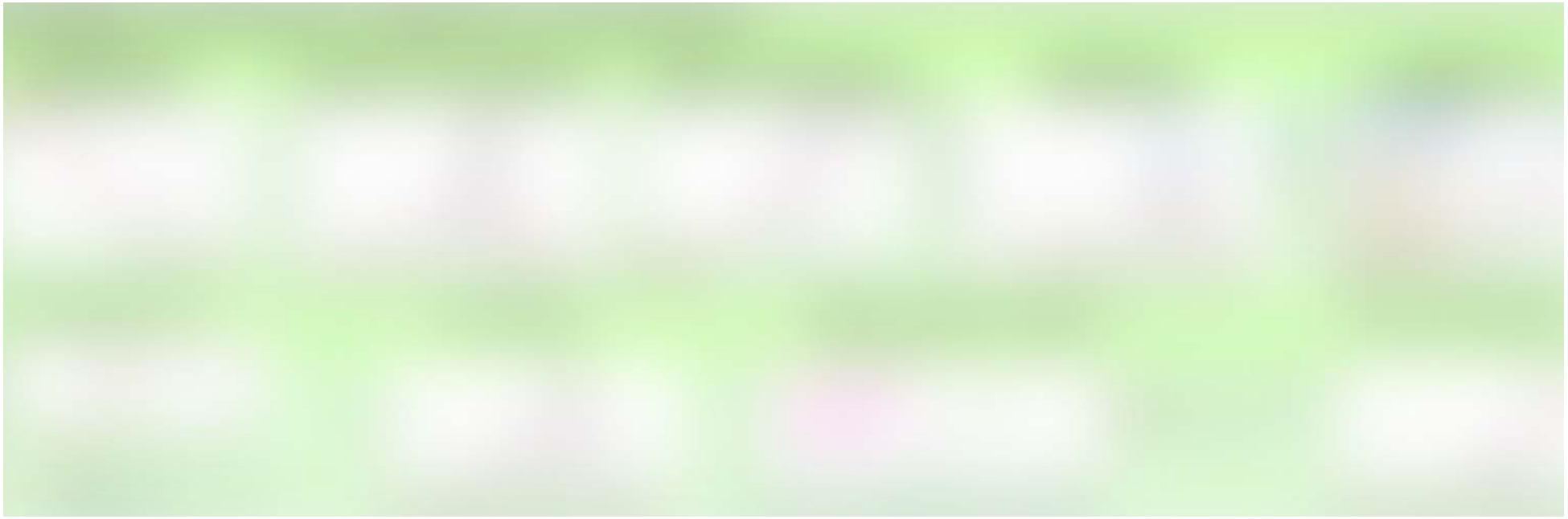
1 July Dharavi Covid 19 Localisation Model Dashboard

The model shows that the authorities' interventions result in cutting the expected deaths in half, from 6000 to 3000.

But there's more.

Since the lockdown release, all social distancing has stopped. When we heard this, we thought, 'Oh-no, what a disaster!' But then we tested this in the model. Counterintuitively, this can actually help, though to produce a positive result, it requires intensive testing and monitoring to avoid too many infections overwhelming the healthcare system. By letting people circulate sufficiently to catch the infection at this stage, and then providing them with good hospital care at a time when the hospitals have sufficient capacity, this can help avoid potential hospital overcrowding at a later stage. Also, more people who might have just stayed home can go

to the hospital and recover. This is the picture if we implement those changes to the simulation:



1 July Dharavi Covid 19 Localisation Model Dashboard

The result is an earlier, lower peak in infections; more severe cases get adequate treatment, and the outbreak is over and done with in Dharavi by early September, instead of dragging on until November. Deaths are reduced to 2400.

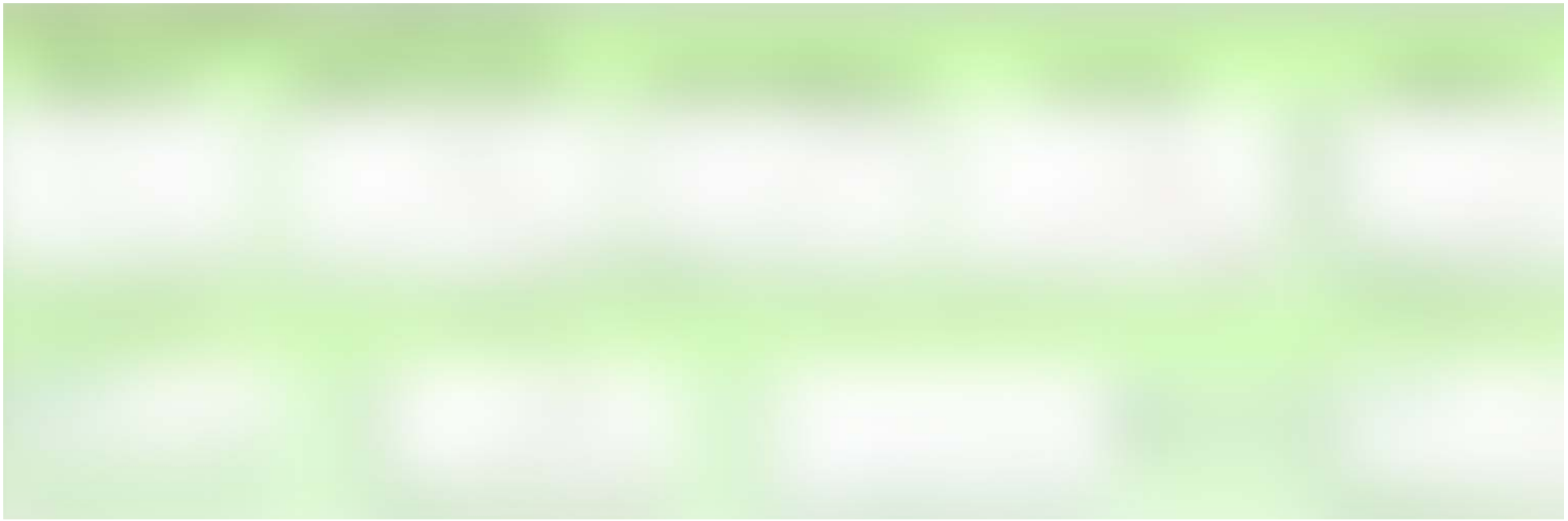
But that's still not all.

There may be scope to isolate more vulnerable people as the pressure is taken off, and as long as complacency does not set in. If the BMC can

double the number of shielded vulnerable people from 6,500 to 13,000, the simulation calculates deaths would be reduced to 2100.

But there is one other looming issue: returning migrants.

Some 350,000 people have left Dharavi, many are expected to return. Here is what happens if they return after the Monsoon. Many may be infected:



1 July Dharavi Covid 19 Localisation Model Dashboard

The impact offsets the gains from shielding the additional people: deaths increase to 2370. That is partly explained by two things: in the model, Dharavi only accepts back people who are not severe cases, and

vulnerable people are not released from quarantine. If vulnerable people are released much earlier in September, the deaths in Dharavi climb back up to 2630. But this can't be evaluated in isolation: it's an issue for the city as a whole if Dharavi experiences another outbreak, even a small one, while there are still many susceptible people next door in Mumbai City District.

So, where do things stand in Dharavi? It looks like the BMC have done a great job in Dharavi. But there is still more that can be done. Some of the actions that at the time seemed very significant have only a limited impact, while others, that seem more modest, have a huge one. The real insight is that the BMC have come up with a very powerful combination of interventions — and there are even some additional opportunities where they could do even better. While there is really tough challenge ahead in Dharavi, those in the bordering neighbourhoods might be even tougher.

Chapter 3: End of June: We are feeling less panic about Dharavi but now we are very concerned about Mumbai City District

With help from Praja we have been able to find good data for the rest of Mumbai City District. There is a fantastic source, published by the BMC, that has recently been reporting what has been happening: we believe this to be just about the best summary of data from any city anywhere in the world.

It has been a somewhat humbling experience to examine this data because it has showed us that what we had thought were clever attempts to estimate what was happening in Mumbai City District, based on Dharavi data, would have produced a massive underestimate. In Chapter 1 we had decided to double the estimates of how fast the infections are spreading in Dharavi because the trend appeared to track a pattern similar to that seen in New York City, where our model indicates that everyone had been infected. We used the excess deaths in New York City to scale up the Dharavi data to account for what we thought might be underreporting. And we applied this same scale up factor to Mumbai City District. By a sheer stroke of luck this turned out to be right. It is yet another illustration of how critically important it is to go straight to whatever source of data you can find to get verified information.

So, what has changed? Quite alot.

We had estimated the number of recorded infections in Mumbai City District at about 7700, and the number of deaths at 300. But, scaled up, this came to 15,500 and 600 at the end of May. When we set up the data from BMC, we found the actual outcome turned out to be about 12,500 recorded cases and 650 deaths, so we have re-set the model to follow this data, now without the scaling up. We know for certain that at least an order of magnitude more infections have happened than this; it's also possible that many deaths have gone unrecorded. However, our model helps correct for this because it accurately follows the epidemiology. These figures can still be subject to revision. In the UK, for example, it

was discovered that a very large number of deaths had been happening outside hospital. We are making an assumption that something similar is also happening in Mumbai but, as yet, we do not have verified data on this. If the data becomes available subsequently, and the numbers prove to be different to our assumptions, then the pace and scale of the outbreak in the model will change.

The next chart shows the simulation (blue line) tracking close to the actual data (red line) for: new cases per day, cumulative new cases, deaths per day, and cumulative deaths. It's not conclusive proof of the model's validity, but it does explain the data based on the epidemiology from Wuhan, with an adjustment of 10% more deaths from co-morbidities in Mumbai City District.

1 July MCDXD Covid 19 Localisation Model

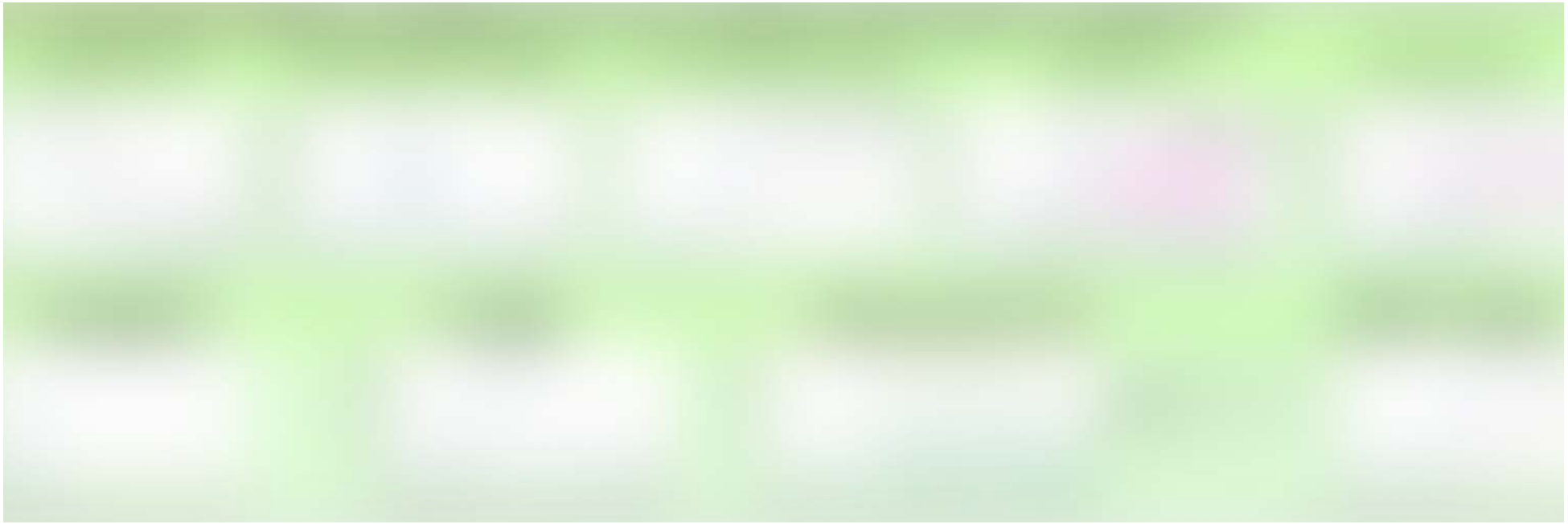
So, what are we concerned about? This is the base case plus a scenario removing migration:

1 July MCDXD Covid 19 Localisation Model Dashboard

You can look at the detail in the model. The main point is that not much has changed from Chapter 1. All the changes and verified data from BMC for the MCDXD wards increase our estimate of deaths without migration from 32,000 to 50,000. results in a Migration reduces the projection 46,000. The problem remains, however, that the hospitals will be crushed by the arrival of new cases in early August.

However, there is time to act: the findings back at the end of May still apply. If measures are taken to isolate 1.6% of the population (35,000

vulnerable people) this will save 9,000 lives. If infection rates are managed with extra vigilance in terms of hygiene and social distancing, this alone saves 14,000 lives. If both are implemented together, 18,500 lives are saved and the number of deaths in Mumbai City District drops to 26,500 or 19,500 saved:



1 July MCDXD Covid 19 Localisation Model Dashboard

However, unlike in Dharavi, where it seems possible, in the absence of return migration, to get through the worst of the outbreak by September, in Mumbai City District, the outbreak will run until at least at least December 2020. With isolation and hospital crowding management in place, the outbreak will last until October 2021.

We are not done with our analysis in Mumbai City District. We will need to think through how to manage returning migrants after the Monsoon. Hopefully, it is self-evident that the Covid-19 localisation model is useful for this task.

Chapter 4: What about all the migrants who have spread out across India taking Covid 19 with them?

We have carried out an analysis of a similar migration seen in Indonesia, though we have not done this for India. The migration in Indonesia has kick-started outbreaks across the country and the disease is now spreading quickly. That migration took place at the end of May. The estimated number of deaths across the country is sobering between 200,000 and 700,000, for a population of 260 million outside Jakarta. Indonesia has implemented measures to battle the spread and we hope they will be successful.

We are at the beginning a program to train young people to localise the use of this model across Indonesia, India, Haiti and the Dominican Republic enabling them to do the same type of analysis as seen in this paper. Our hope is that these initiatives will complement the efforts of the local authorities, as we believe has already been the case in Dharavi and will hopefully continue to be the case in Mumbai.

Chapter 5: What's next and other observations?

Clearly, the circumstances in Mumbai are not unique to that city alone. The same scenario is repeated in hundreds of cities across the world, where poor, crowded neighbourhoods interact closely with wider urban areas (though, it needs to be noted, that the Monsoon adds an especially heavy burden in Mumbai). While tailoring strategies for contrasting neighbourhoods adjacent to each other is undoubtedly a challenge, putting in place such differentiated strategies can offer massive improvements in outcome over a one-size-fits-all approach.

Since we wrote Chapter 1, this analysis has resonated with young people, healthcare professionals, NGOs, and data science consultancies. Student-led teams and other similar teams have been formed and are applying these methods in Athens, Haiti, Dominican Republic, Hyderabad, Jakarta, California, Florida, New York City, Ohio, and Texas.

The open source model used in producing these results has been tested in many different regions throughout the world. It is easy to use and understand and has even been used by secondary school students, who quickly learned how to use it. The model can be localised to any chosen city or area and can be used by anyone with reasonable common sense, including the non-modelling community and healthcare professionals. For those who wish to start on their locality: please try this online course that takes you step by step through the process — it is free for personal use.

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Richard Kock is Professor of Wildlife Health and Emerging Diseases at the Royal Veterinary College London, Kim Warren and Maurice Glucksman are specialists in dynamic modelling. Shankar Suryanarayanan is a life sciences manufacturing consultant. He grew up in Mumbai City District and has family there now. Hasna Virk, currently studying Biomedical Sciences at University of Warwick, and Andre Nemec, who will start at University of Bristol in September. We want to thank all the people in Praja who have helped us improve our understanding of the conditions in Mumbai and found data for us that would be impossible to get any other way. We also thank Partha Bose and Ivan Hutnick who both helped to ensure the ideas here are more clearly communicated. And we thank all of the Covid 19 Localisation Group volunteers who collectively have made this work possible.

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